The Polarized ³He Target for the Measurement of the Electric Form Factor of the Neutron, G_E^n at High Momentum Transfers

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for the GEN and the Hall A Collaborations

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Physics Motivation	The Polarized ³ He Target	Target In-Beam Performance	Innovations	Summary
Outline				

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Physics Motivation

- On the Neutron
- Neutron Target

2 The Polarized ³He Target

- The Target Cell
- Polarizing the Target
- The Target Setup

3 Target In-Beam Performance

Innovations

5 Summary

Physics Motivation ●○	The Polarized ³ He Target	Target In-Beam Performance	Innovations	Summary
On the Neutron				
The Neutron s	o far			

• The Elastic Cross Section:

$$\frac{d\sigma}{d\Omega} = \left(\frac{d\sigma}{d\Omega}\right)_{Mott} \frac{E'}{E} \left(\frac{G_E^2 + \tau G_M^2}{1 + \tau} \cos^2\frac{\theta}{2} + 2\tau G_M^2 \sin^2\frac{\theta}{2}\right) \Longrightarrow \text{Dominated by} G_M$$

 $au = Q^2/4M^2$

 The Jefferson Lab Hall A Gⁿ_E experiment was a double polarized experiment with polarized electrons and polarized neutrons.



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Physics Motivation ○●	The Polarized ³ He Target	Target In-Beam Performance	Innovations	Summary
Neutron Target				
A Polarized	Neutron Target			

- Free neutrons have a lifetime of about 15 minutes
- ³He as an effective polarized neutron target:
 - Effective neutron polarization ~86%; proton contribution is suppressed
 - Luminosity achieved was $\mathcal{L} = 0.5 \times 10^{36} \text{ cm}^{-2} \text{s}^{-1}$ with $8\mu A$ electron beam
 - Can be polarized using optical pumping method change this!!



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Physics Motivation	The Polarized ³ He Target ●○○	Target In-Beam Performance	Innovations	Summary
The Target Cell				



Physics Motivation	The Polarized ³ He Target ○●○	Target In-Beam Performance	Innovations	Summary
Polarizing the Target				



Physics Motivation	The Polarized ³ He Target ○○●	Target In-Beam Performance	Innovations	Summary
The Target Setup				





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Physics Motivation	The Polarized ³ He Target	Target In-Beam Performance	Innovations	Summary

- About 100W of circularly polarized infra-red laser light (795nm) incident on 3.5" diameter target pumping chamber.
- Target polarization monitored regularly with NMR, calibrated with EPR





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The Polarized ³He Target

Target In-Beam Performance

Innovations

Summary

Iron Target Box

With the iron target box, a holding field uniformity of 10mG/cm was achieved near the BigBite spectrometer's 1.2T field.





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Comparison with Earlier Hall A ³He Experiments

Component	Earlier Expts.	This Experiment	
Alkali Metal	Rb (170°C)	Rb+K (245°C) \rightarrow <i>hybrid</i>	
	Spin-up time	Faster spin-up (\sim 6 hrs) and higher	
	\sim 12 hrs	polarizations	
Compass	0.3°	0.1°	
Resolution		Precise angle measurement resulting	
		in reduced error in Asymmetry	
Spectrometer	6msr	75msr	
Solid Angle		Operation very close to the target	
		because of Iron Target Box	
Laser Light	Laser Hut	Optical Fibers	
Delivery	in Hall	Operation from outside the	
		Hall saved Hall floor space and time	
Polarizing	4 sets	One set	
Optics		Compact Optics and Easier	
		Installation	

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- Hall A experiment G_E^n at High Q^2 ran successfully in Spring 2006.
- The target ran smoothly and continuously for three months (with high density and high beam current).
- Future Hall A ³He experiments using the G_E^n target experience.

G_E^n Innovations

- Target polarization around 50% a record.
- Magnetic field direction measured precisely to better than 0.1°.

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- New ...
 - ... hybrid cell technology
 - ... fiber combiner and optics
 - ... air-floated precision compass
 - ...target magnet box

Next talk on the G_E^n Neutron Detector ...